Museum Education: Integration of Cultural Heritage and Educational Metadata Schemas

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Abstract. The emergence of museum education aims at incorporating cultural heritage content within educational metadata frameworks in order to educate versatile individuals, equipped to navigate the complexities of a globalised world. The work navigates through the challenges and benefits of this integration, proposing the development of a unified metadata model for museum education as an incremental step towards improved learning experiences in the digital age. Accordingly, this work proposes the merging of EDM, LOM, and IMS LD metadata schemas so as to enhance the delivery and engagement of educational content by amalgamating it with cultural heritage content. This is achieved through the development a model focused on enhancing learning through CH and its evaluation as far as the opportunities and challenges of this integration through a case study. The case study is centred on the Ionian University Museum's collections and specifically the "Duplicating Machine Gestetner No 1193069". The pedagogical benefits of the proposed approach are then showcased, emphasising the enriched learning environment it creates. Thus, the case study demonstrates the feasibility and capability of the model to provide information that will engage students with CH, connecting them with historical and cultural narratives in a meaningful way by integrating detailed cultural and historical insights into the learning process.

Keywords: Europeana Data Model (EDM) · Learning Object Metadata (LOM) · IMS Leaning Design · Metadata Model Amalgamation · Museum Education

1 Introduction

In the evolving landscape of education, the incorporation of digital resources has become paramount to fostering engaging and comprehensive learning environments. The emergence of standardised metadata models such as IMS Learning Design (IMS LD)[1], Learning Object Metadata (LOM)[2], and Europeana Data

[1] https://www.imsglobal.org/home.
[2] https://www.ieee.org/.

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Model (EDM)[3] marks a significant move towards adopting standardised digital resources for delivering educational content. This shift is parallel to the dynamic field of museum education, which embraces not just preservation and documentation but is constantly evolving to address the changing needs and expectations of a diverse audience [15]. At the heart of this evolution is the integration of XR technologies, allowing museums to craft immersive and accessible educational experiences that transcend physical boundaries [6]. This study delves into the significance of these frameworks in the context of educational content delivery and Cultural Heritage (CH), underscoring the importance of integrating CH content within educational frameworks to enrich learning experiences [9]. Furthermore, it outlines the objectives of this integration, highlighting the challenges and potential benefits inherent in merging CH with educational curricula. The ultimate goal is to develop a unified metadata model for museum education, potentially revolutionising learning experiences in the digital age [14].

1.1 Motivation and Contribution

Incorporating CH into educational curricula significantly enriches the learning process, offering students access to a broad spectrum of knowledge, traditions, and viewpoints. This strategy not only broadens and contextualises learning content but also enhances cultural awareness and empathy. Engaging with CH promotes critical thinking and creativity, fostering a multidisciplinary approach to education. Such integration cultivates versatile individuals, equipped to navigate the complexities of a globalised world. In light of this, the contributions of this paper are:

- the development a model focused on enhancing learning through CH,
- the evaluation of the opportunities and challenges of this integration through a case study.

The remainder of this document is structured as follows: A historical overview provides essential context for appreciating the importance of integrating these models. Following the historical overview, Sect. 3 explores the methods used to combine these different metadata models and the challenges that arise from this effort. Section 4 focuses on the presentation of a educational learning activity illustrating the procedure of incorporating EDM metadata into learning objects. Section 5 addresses the challenges associated with the integration. The paper concludes in Sect. 6 with a summary of the document's main arguments, reiterating the importance of integrating EDM metadata within IMS LD using LOM to enhance educational experiences.

2 A Historical Background of Metadata Models

Metadata models have evolved from simple classification systems in older libraries to advanced digital cataloguing, highlighted by the MARC format [2]

[3] https://www.europeana.eu/en.

in the 1960s and 1970s, which automated data exchange between libraries. The advent of the Internet led to the creation of the Dublin Core Metadata Element Set [1], facilitating standardised digital resource management. This was followed by domain-specific standards like IPTC[4], EAD [12], and CCO [11], catering to unique needs. Recent trends emphasise linked data and the semantic web to improve data connectivity with standardised ontologies. The Dublin Core Metadata Initiative stands out for its versatility across various domains, especially in CH institutions, by providing essential elements for organising digital resources. However, for complex collections, these institutions may need additional, domain-specific standards for a more nuanced contextual representation.

In the education sector, metadata models began to take shape with the LOM model by the IEEE Learning Technology Standards Committee [5], laying the foundation for subsequent standards. LOM focuses on the description of digital content itself. It is a standard for specifying the metadata of learning objects, which are any digital resources that can be used, reused, or referenced during technology-supported learning. By facilitating the categorisation and retrieval of digital resources, LOM enhances the accessibility and reusability of educational materials across different platforms and disciplines.

EML [8], developed later, aimed to encapsulate the entire pedagogical context, offering a comprehensive framework for coherent learning experiences. EML, evolving into the Learning Design Information Model by IMS[5], highlighted the necessity of a structured approach to represent educational content. It also emphasised the importance of sequences and interactions in the learning process. IMS LD is a specification that provides a standardised way to describe the methodology and structure of an educational course, allowing educators to design, share, and deliver customizable and adaptive learning experiences. It emphasises the dynamic aspect of learning, accommodating various pedagogical approaches and fostering an interactive learning environment.

EDM[6] is a framework designed by Europeana to facilitate the integration, sharing, and accessibility of digital CH collections across Europe. Despite EDM's capacity to model cultural content potentially for educational uses, it is not primarily intended for this purpose. Its primary focus is on the aggregation and accessibility of digital CH, not on the nuanced requirements of educational content modeling. This limitation is crucial to acknowledge as it indicates that, while EDM can support educational activities by providing access to cultural resources, it may not sufficiently cater to the specific needs of educational content development, such as aligning with learning objectives, pedagogical strategies, or the nuanced representation of educational themes and concepts. The gap between EDM's capabilities and the specialised demands of educational content modeling highlights the need for additional frameworks or adaptations that specifically address the intricacies of educational material design and implementation.

[4] https://www.iptc.org/.
[5] http://www.imsglobal.org/home.
[6] https://bit.ly/447BEZ3.

In context of museum education, metadata models have gained paramount importance in the preservation and dissemination of CH assets [4]. The implementation of these models ensures efficient organisation and dissemination of CH resources, promoting cultural appreciation and education for future generations. At the same time, the integration of XR technologies into cultural institutions offers unparalleled opportunities for enhancing educational experiences and deepening connections with CH [10]. However, to harness the full potential of XR in museum education, well-designed data models are needed that ensure interoperability and organised data handling. While existing research has demonstrated maturity and standardisation in metadata models for cultural institutions, there is a lack of similar development in the fields of education and XR. It is also noteworthy that there has been very little research on the integration of these three thematic pillars in metadata models [13].

3 Methodology

3.1 The Process of Amalgamation

This part of the work explores the complexities of structuring information specifically for museum education contexts. Previous study [13] has thoroughly examined various aspects of this topic, including the foundational background, historical developments, and recent progress in the fields of education and cultural institutions. These discussions point out that, although standards and metadata models are established in each area, their integration to meet the unique needs of museum education presents considerable challenges. To address these issues, this section delves into the methods involved in combining or merging metadata.

The goal of merging these models is to create an all-encompassing approach that addresses all facets of educational methodologies reliant on cultural heritage institutions. This strategy is expected to overcome the limitations and fill the gaps found in individual models, offering a more streamlined and effective way to manage metadata within museum education. The proposed integrated framework aims to enhance educational experiences and foster stronger connections with CH for museum visitors combining different metadata models entails a sequence of actions aimed at harmonizing and uniting various metadata frameworks, as described in previous research [13].

This process begins with a thorough understanding of the metadata models involved, followed by mapping and alignment to identify commonalities and differences. The next step, normalisation, aims to standardise the data formats and values, facilitating data transformation to adjust and convert data according to the unified model. A data fusion strategy is then implemented to integrate the data seamlessly, ensuring that the merged dataset is coherent and comprehensive. This is followed by validation and quality assurance to guarantee the accuracy and reliability of the integrated data. Testing and iteration are critical for refining the integration process, making necessary adjustments based on feedback and performance. Lastly, documentation is essential to record the

methodologies, decisions, and outcomes of the integration process, providing a reference for future endeavors in merging metadata models.

3.2 The IMS Learning Design Level A

IMS LD is a framework created by the IMS Global Learning Consortium (see Footnote 5) for modeling educational processes. It supports various pedagogical models across three complexity levels: Level A, B, and C, each offering increasing features for more advanced learning designs. Level A is the base level of the IMS LD specification. It offers the core elements necessary to model a wide variety of pedagogical approaches. It allows educators and instructional designers to describe the learning objectives, activities, roles, and resources involved in a learning process, along with the sequencing of these activities. The specification is designed to support a wide range of pedagogical models, from traditional instructor-led training to more collaborative and student-centered approaches. It encompasses several key components (Fig. 1):

- **Roles:** Define the participants in the learning process, such as learners and instructors, and their responsibilities.
- **Activities:** Specify the tasks that learners and instructors need to perform, which can be individual or collaborative.
- **Environment:** Describes the learning resources and services that support the activities, including content objects, tools, and communication facilities.
- **Method:** The overarching structure that orchestrates roles, activities, and environments into a coherent learning flow.

3.3 Integrating IMS Learning Design, LOM, and EDM: A Unified Approach

EDM and LOM standards serve two distinct purposes but have potential overlaps that allow for integration as shown in Fig. 2. EDM is designed primarily to describe and link CH objects in a way that supports the Europeana portal's goal of making European CH accessible online. LOM, on the other hand, is designed to describe educational resources in a way that facilitates their use and reuse in learning environments. Despite their different focus, their amalgamation can enrich the educational context with CH content.

The integration of LOM into IMS LD represents a innovative blend of two distinct educational frameworks. Although IMS LD does not explicitly require the use of LOM, the rich and comprehensive nature of LOM serves as an invaluable guide for enhancing the description of learning objects within IMS LD [7]. This influence of LOM on IMS LD allows for the borrowing of elements and structures that contribute to a more detailed and informative description of learning objects. For example, incorporating LOM's detailed specifications such as the format, type, interactivity level, or intended end-user role can significantly enrich the resource description in IMS LD.

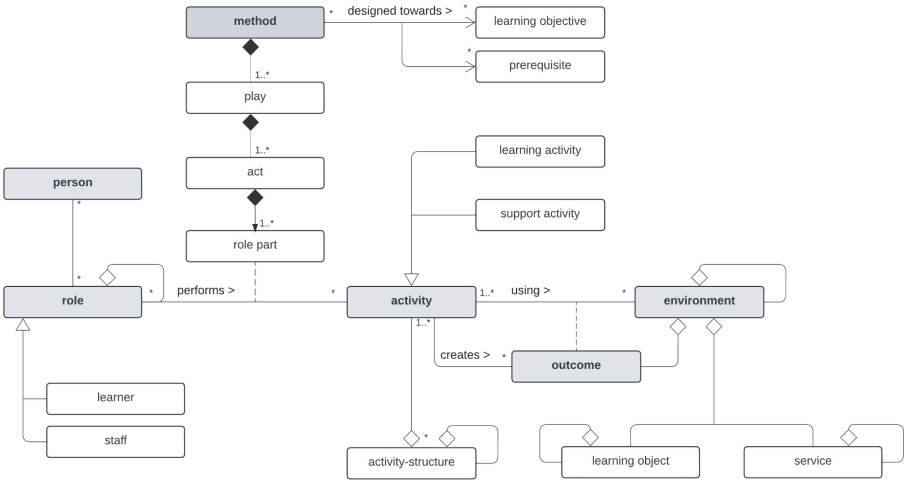

Fig. 1. The IMS Learning Design Conceptual Model.

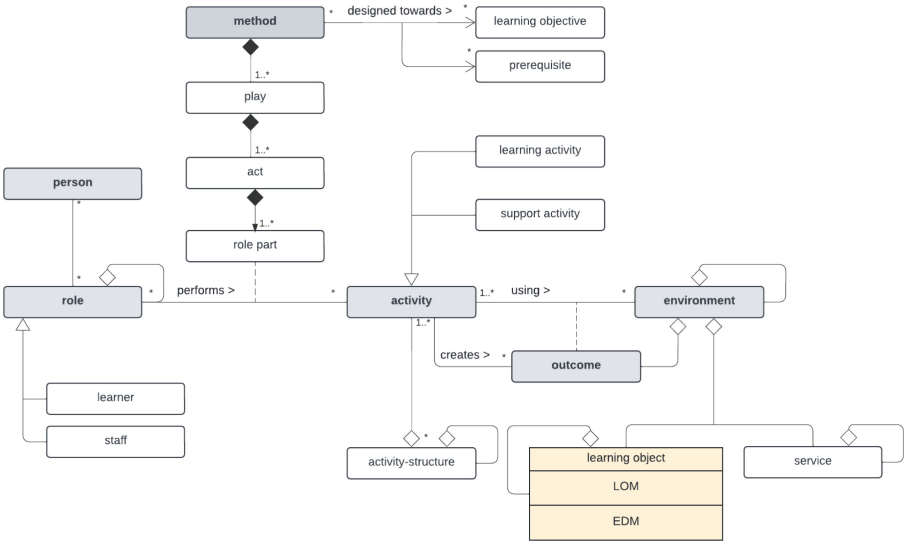

Fig. 2. The IMS Learning Design Conceptual Model with the inclusion of LOM and EDM metadata.

Moreover, the relationship between LOM and IMS LD extends beyond mere influence to adaptation. This involves a more direct incorporation of LOM elements into IMS LD's resource descriptions, but tailored to align with the specific requisites of the IMS LD framework. Such an adaptation proves advantageous as it capitalises on LOM's comprehensive nature in detailing educational content. This synergy not only enhances the clarity of the resource descriptions but also

bolsters the overall usability of learning objects in a variety of learning design contexts. By integrating these elements from LOM, IMS LD can benefit from a more robust framework for describing learning resources, thereby facilitating a clearer understanding and more effective use of these resources in educational settings.

In the IMS LD framework (see Footnote 5), learning objects are often part of the "Environment" component, treated as "resources", digital or non-digital. These resources support the learning activities described in the design. Examples include web pages, textbooks, productivity tools, instruments, and test items. The metadata for these learning objects can be detailed within the resource element and while it doesn't strictly adhere to the LOM standard, it can be influenced by or adapted from LOM [3].

Mapping data from the EDM to the LOM involves identifying equivalent or relevant elements between the two formats and translating the EDM content into the structure and fields required by the LOM specification as shown in Table 1. This could involve, for instance, mapping the title, description, and keywords from EDM to similar fields in LOM, as well as possibly incorporating links to digital resources.

Table 1. EDM metadata elements mapped to LOM classes and properties.

EDM Property	LOM Property	Sample data
edm:ProvidedCHO .dc:identifier	1.1 General.Identifier.Entry	Μ.Γ.38
edm:ProvidedCHO .dc:title	1.2 General.Title	Duplicating Machine Gestetner No 119306
edm:ProvidedCHO .dc:description	1.4 General.Description	Ink Polygraph. Manual. Material: Metal, Wood. Dimensions: $43 \times 74 \times 53$ cm
edm:ProvidedCHO .dc:type	1.5 General.Keyword	Typewriter
edm:ProvidedCHO.dcterms:provenance	3.2 Meta-Metadata.Contribute.Entity	Donation
edm:ProvidedCHO.dcterms:medium	4.1 Technical.Format	Manual
edm: WebResource.dc:format	9.3 Classification.Description	image/jpeg

4 Case Study

To illustrate how the combination of EDM, LOM, and IMS LD metadata schemas enhances the delivery and engagement of educational content, let's consider a concrete example within the context of a case study focused on the Ionian University Museum's collections, particularly on the Duplicating Machine Gestetner No 1193069.

1. **Contextualising the Artifact with EDM**: Utilising EDM, the Duplicating Machine Gestetner No 119306 is provided with a rich cultural and historical context that highlights its provenance, historical significance, and

role in advancing printing technology. Metadata elements associated with the machine enrich the understanding of its impact and development. In a practical application of this framework, students can access an interactive timeline that features high-resolution images of the Duplicating Machine, historical documents pertaining to its invention, and multimedia resources that detail its influence on the printing industry and broader society. Each of these resources is tagged with EDM metadata, enabling students to thoroughly explore the artifact's background and appreciate its significance in technological history.

2. **Structuring Educational Resources with LOM**: Employing LOM to categorise and describe educational resources related to the Duplicating Machine ensures that metadata elements effectively highlight the educational level, learning objectives, interactivity level, and intended end-user role. An example of this application is the development of an online learning module that features instructional videos on the operation of the Duplicating Machine, readings on the history of printing technologies, and interactive quizzes. LOM metadata plays a crucial role in making these resources easily searchable and aligning them with specific learning objectives, such as understanding historical printing techniques. This structured approach enhances the educational utility of the content and facilitates a more targeted learning experience.
3. **Pedagogical Framework with IMS LD**: Utilising IMS LD to structure the learning activities, roles, and sequencing of educational content provides a clear framework that outlines the roles of students and instructors, as well as the activities involved, such as viewing, interacting, and researching using various resources like videos, articles, and quizzes. An example application of this approach is the design of a blended learning activity. In this setup, students initially engage with online resources categorised through Learning Object Metadata (LOM), which then transition into hands-on workshops using replicas of the Duplicating Machine. IMS LD is instrumental in facilitating the design of this blended approach, ensuring a seamless flow from theoretical understanding to practical application, enhancing the learning experience by bridging digital and physical learning environments.

While an educational scenario could be developed without EDM data, using EDM alongside IMS LD and LOM enhances the learning experience significantly. EDM's rich contextual information, combined with IMS LD's structured learning design, provides an interactive exploration of the Duplicating Machine's historical significance. LOM's customisation of learning resources to match educational levels and styles improves accessibility, while IMS LD facilitates adaptable learning paths tailored to student feedback. This integrated approach allows students to engage deeply with both the technical and cultural aspects of the Duplicating Machine, fostering a comprehensive and engaging learning experience.

4.1 Learning Activity on the Collections of the Ionian University Museum

Use Case Scenario

- **Title:** Journey to the Era of the Flourishing of Printing Art: Exploring the Duplicating Machine Gestetner No 119306[7]
- **Pedagogy/type of learning:** This course is designed as a blended learning experience, combining elements of individual research and group collaboration. It's aimed at providing a comprehensive understanding of historical printing techniques, specifically focusing on the Duplicating Machine Gestetner No 119306.
- **Description/context:** This course is a part of a broader curriculum on historical printing technologies. It is designed for students with basic knowledge of printing history and techniques. The course delves into the operation and significance of the Duplicating Machine Gestetner No 119306, a pivotal machine in the evolution of printing technology. Students will explore its historical context, mechanics, and impact on the printing industry.
- **Learning objectives:** The primary objective is for students to gain an in-depth understanding of the Duplicating Machine Gestetner No 119306, including its design, functionality, and role in the history of printing. Additionally, students should be able to critically analyse its influence on modern printing technologies.
- **Roles:** The primary role is that of the student. Instructors and guest lecturers from the field of historical printing technology will also play significant roles in delivering content and facilitating discussions.
- **Different types of learning content used:** The course employs a mix of interactive lectures, hands-on workshops, digital resources, and historical documents. Learning materials include video tutorials on the duplicator's operation, readings on printing history, and case studies of significant printing projects accomplished with the Duplicating Machine Gestetner No 119306.
- **Different types of learning services/facilities/tools used:** The course will utilise an online learning platform for distributing materials and facilitating discussions. Physical workshops will be conducted in a lab equipped with a functioning Duplicating Machine Gestetner No 119306 duplicator and related printing tools.
- **Different types of collaborative activities:** Students will engage in group projects, such as reconstructing historical printing projects using the Duplicating Machine Gestetner No 119306. Online forums and discussion groups will also be used for collaborative learning and peer reviews.
- **Learning activity workflow (how actors/content/services interact):**
  1. **Introduction Block:** History of Printing Technology and Introduction to the Duplicating Machine Gestetner No 119306.
  2. **Practical Block:** Hands-on workshops on operating the Duplicating Machine Gestetner No 119306, supplemented by video tutorials and instructor guidance.

[7] https://museum.ionio.gr/en/collections/typography/12/.

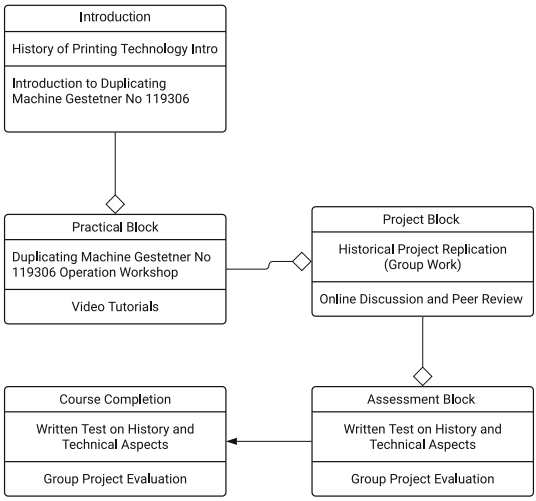

Fig. 3. UML Diagram of the activity "Journey to the Era of the Flourishing of Printing Art: Exploring the Duplicating Machine Gestetner No 119306"

3. **Project Block:** Students work in groups to replicate a historical printing project using the Duplicating Machine Gestetner No 119306. Online discussions and peer reviews complement the project work.
4. **Assessment Block:** Combination of a written test covering the historical and technical aspects of the duplicator and evaluation of the group project. The course is structured sequentially, with each block building upon the previous. Interactive elements like forums and video tutorials are accessible throughout the course duration.

– **Other needs/Specific requirements:** None.

The UML Diagram. The UML activity diagram as per Fig. 3, based on the "Journey to the Era of the Flourishing of Printing Art: Exploring the Duplicating Machine Gestetner No 119306" use case, would depict a structured learning pathway where students progress through introductory material, engage in practical exercises, collaborate on a project, and finally undergo assessment, with decision points ensuring readiness for each stage.

4.2 The Integration Process

The first step in integrating CH metadata is to identify learning objects that could benefit from it. The selection is guided by the learning objectives and the potential pedagogical value that EDM elements could contribute to each object, as mentioned in Sect. 3.3 Table 1. The outcome of this process, including the detailed mapping of CH metadata to learning objects, is illustrated in Figs. 4 and 6.

A critical step in this process involves specifying namespaces and harmonising schemas to guarantee they are compatible and can be validated against both LOM and EDM standards. This process ensures that information from different systems can be seamlessly exchanged and understood. For example, in the context of IMS LD, an XML document might declare its namespaces in a way that delineates different parts of the metadata model. To illustrate, the XML document might include namespace declarations at the beginning of the document, indicating which elements belong to the LOM schema, as per Fig. 5.

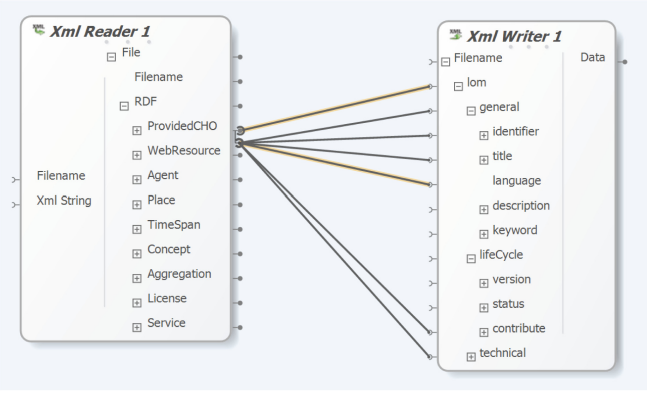

Fig. 4. Visual mapping of EDM to LOM elements

```
<?xml version="1.0" encoding="UTF-8"?>
<imsld:learning-design
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.imsglobal.org/xsd/imsld_v1p0 http://www.imsglobal.org/xsd/IMS_LD_Level_A.xsd
    xmlns:imsld="http://www.imsglobal.org/xsd/imsld_v1p0"
    xmlns:lom="http://ltsc.ieee.org/xsd/LOM"
    xmlns:edm="http://www.europeana.eu/schemas/edm/"
    level="A"
    uri="UniqueIdentifierForLearningDesign" identifier="YourLearningDesignID" version="1.0">
```

Fig. 5. Declaration of LOM namespace in IMS LD schema

5 Challenges of Integration

Integrating LOM and EDM requires careful navigation of their structural and semantic differences. LOM focuses on educational resources, highlighting elements like educational level, learning objectives, and pedagogical strategies, while EDM is tailored for CH artifacts, emphasising origin, cultural context, and historical relevance. For instance, LOM's schema includes detailed classifications for educational use, whereas EDM offers rich descriptions for object collection and curation history. This necessitates a thoughtful approach to ensure

```
<!-- Environments -->
<environments>
    <!-- Environment for "Research and Preparation on Duplicator" -->
    <environment identifier="classroomEnvironment1">
        <title>Classroom Environment for Research and Preparation on Duplicator</title>
        <learning-object identifier="lo_la1_1">
            <item identifier="item_la1_1">
                <title>Study the history of printing technology.</title>
            </item>
            <imsld:metadata>
                <lom:lom>
                    <lom:general>
                        <lom:identifier>
                            <lom:catalog></lom:catalog>
                            <lom:entry>M.Γ.38</lom:entry>
                        </lom:identifier>
                        <lom:title>
                            <lom:string language="en">Duplicating Machine Gestetner No 119306</lom:string>
                        </lom:title>
                        <lom:description>
                            <lom:string language="en">Ink Polygraph. Manual.Material: Metal, Wood.Dimensions: 43 x 74 x 53 cm</lom:
                        </lom:description>
                        <lom:keyword>
                            <lom:string language="en">Typewriter</lom:string>
                        </lom:keyword>
                    </lom:general>
                    <lom:lifeCycle>
                        <lom:contribute>
                            <lom:role>
                                <lom:value>publisher</lom:value>
                            </lom:role>
                            <lom:entity>Ionian University</lom:entity>
                        </lom:contribute>
                    </lom:lifeCycle>
                    <lom:classification>
```

Fig. 6. IMS LD XML snippet

both models retain their unique characteristics while becoming interoperable for educational use.

To address this issue, a custom mapping strategy was developed. This involved creating a crosswalk-a detailed guide that maps elements from one metadata schema to another. The crosswalk identified equivalent elements between LOM and EDM and provided rules for transforming and harmonising data. For instance, the edm:hasType property from EDM, which categorises the CH object by its nature or genre (e.g., painting, manuscript, sculpture), into the classification element within LOM, utilised to categorise learning objects in an educational context. In the context of a curriculum focused on Renaissance art, a CH object classified under edm:hasType as "Painting" could be seamlessly integrated into the educational platform through a corresponding LOM classification entry, thereby enhancing the module with authentic historical and cultural artifacts.

Integrating EDM and LOM metadata presents the challenge of information overload, risking the creation of overly complex learning objects that can overwhelm users. To maintain usability and accessibility, it's crucial to selectively integrate metadata elements that enhance educational objectives and learning experiences. This approach ensures that integration adds value without sacrificing clarity and effectiveness.

Technical barriers further complicate the integration of LOM and EDM. Schema compatibility issues arise when trying to align the different formats and data structures of the two models. For instance, LOM might use a specific format for representing dates or educational levels that differs from EDM's approach. Namespace conflicts also present a challenge, as the same terms or identifiers may be used differently across the schemas, leading to ambiguity and potential misinterpretation of metadata. Overcoming these technical barriers requires a robust

strategy for schema mapping and namespace management, ensuring that the integrated metadata model is coherent, consistent, and correctly interpretable by both educational and CH systems.

6 Conclusion

This study aims to support the landscape of museum education through the development and integration of a unified metadata model, blending the realms of CH with educational frameworks.

Our proposal focuses on merging EDM, LOM, and IMS LD metadata schemas to enhance the delivery and engagement of educational content. This integration is crucial for providing immersive educational experiences, as demonstrated in the case study centered on the Ionian University Museum's collections. Through a detailed exploration of the Duplicating Machine Gestetner No 1193069, the pedagogical benefits of the proposed approach were showcased, emphasising the enriched learning environment it creates.

Evaluated through this case study, the model demonstrated its capability to provide information that will engage students with CH, connecting them with historical and cultural narratives in a meaningful way. The case study not only confirmed the feasibility of the proposal but also highlighted the enriched educational value achieved through integrating detailed cultural and historical insights into the learning process.

Looking ahead, the development of an XML Schema Definition (XSD) that describes the unified metadata model in detail is proposed. This will serve as a cornerstone for future efforts in educational technology, providing a standardised template for incorporating CH into educational content. The XSD will facilitate easier adaptation and implementation by educators and technologists, aiming to broaden the integration of CH across various educational platforms and disciplines. Additionally, future plans include rigorous testing of the model's effectiveness through pilot projects and the collection of extensive feedback from users. As we move forward, cooperation between cultural institutions, technologists, and educators will be essential to the evolution of metadata standards and their instructional uses.

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